# Installation, Integration and Testing Plans (at C0) for the BTeV Muon System

The BTeV Muon Group
BTeV-doc-1036

December 7, 2004

# 1 Introduction

This document describes the installation, integration and testing plans for the BTeV muon system. As described in BTeV-doc-865, the octants shipped to Fermilab will already have undergone a rigorous testing and quality assurance program at the production sites. The individual planks will have had their wire tensions measured, and will have been leak tested. The efficiencies of each tube will have been measured in a cosmic ray test stand, along with their noise rates, current draws at voltage, optimal operating voltages, and so on. Bad front-end electronics channels will have been fixed.

When the planks are assembled into octants, all gas, low voltage, high voltage, signal, and control connections and cables that are internal to the octant structure will be made. These connections will be tested at the production sites prior to shipping to Fermilab, including a full readout test of all channels. They will be ready for installation and, unless they are damaged in shipment, ready to go.

# 2 Transportation of muon detector octants to C0

The octants will be delivered to C0 as they are fabricated at the production sites. They will be stored at C0 or some other appropriate place, and installed during periods in which we have extended access to the hall.

## 2.1 Equipment required

The octants which will be shipped to Fermilab will be too heavy to carry reliably without assistance. A roller cart will be required to move them. The required carts will be built in the Illinois machine shop and shipped to Fermilab and the other octant production site at Vanderbilt University. The octants will be shipped to Fermilab; we are still working out how this will be done. We will either rent trucks and move them ourselves, or ship them with a commercial carrier.

## 2.2 Special handling

The proportional tubes that make up the muon system will be made from stainless steel tubes strung with 30 micron gold-plated tungsten wire. The wires will be held in place with by crimped brass tubes at each end. The planks themselves will be extremely sturdy and strong, and the electronics and other connections internal to the octant will be very robust. The concern with the detectors is that some of the crimps holding the wire in place will fail or that wires will break, especially during shipping. This will be our major concern in determining how we will move the octants to Fermilab.

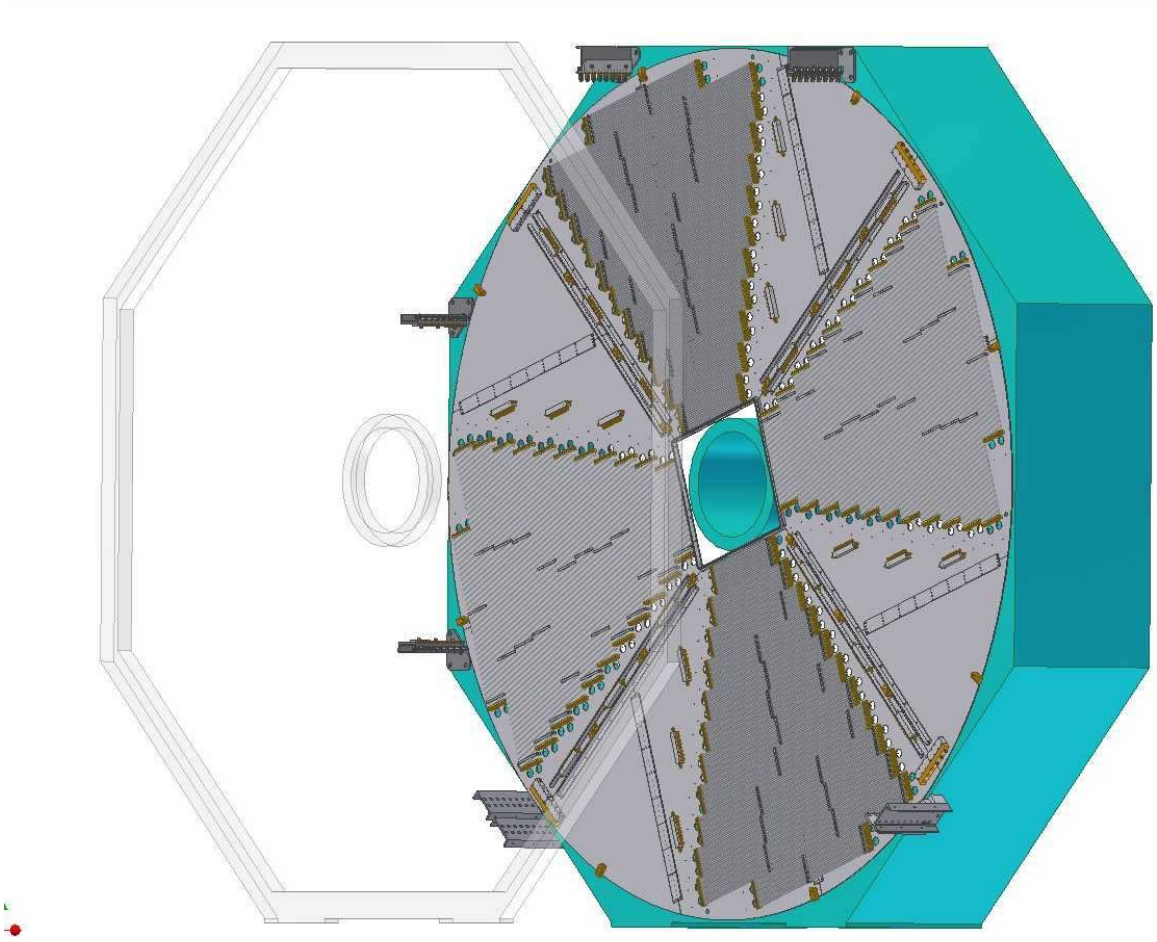

Figure 1: The mounting wheel will be supported from beams attached to the toroid. The upper two beams will support the $\approx$ 1500 lb weight of each wheel, the additional beams will prevent the wheel from swaying.

# 3 Installation of muon system elements at C0

The muon octants are designed so that they can be inserted from the wide aisle side of the detector hall. One dynamically creates a mounting "wheel." The first octant plate is inserted from the side and then rolled to the bottom position on a series of rollers that contact the octant plate circumference. The next octant plate is then attached to the previous plate using specially designed knitter brackets. One then rolls the two octant partial wheel into a position that allows the attachment of the third plate. Once all 4 plates of a wheel are assembled, the wheel is lifted off of the floor and mounted from beams attached to the toroid, as illustrated in Fig. 1 and the floor wheels (bogies) are removed and used for the installation of the next wheel. In all, 8 wheels are used for each station.

The process can be reversed for repairs. In the worse case, the replacement or repairs of

a single plank will require de-cabling its wheel and sequential dismounting and rotation of the wheel until the affected octant is in a convenient position for repairs.

## 3.1 Installation steps

**Testing of octants on arrival:** When the octants arrive at C0 from the production sites, we will retest them with the same test system used at the production sites: testing gas flow, current draw, readout of all channels, etc. Any problems will be fixed.

**Installation of octant support structure:** The octants will then form "mounting wheels" during installation. These mounting wheels will be supported from the sides and top of the toroid and filter using a set of specially designed hangers which attach to fixtures on the wheel assembly.

**Installation of relay racks, gas system, and other support infrastructure:** We assume that the installation of relay racks and other support infrastructure (such as the gas system) will occur as early as possible. Low voltage and high voltage supplies, as well as data acquisition hardware, can be installed as needed (*i.e.* as new octants requiring them are installed, if possible).

**Suspension of octants:** The mounting wheel will be supported from beams attached between the toroids. The upper two beams will support the $\approx$ 1500 lb weight of each wheel as shown in Fig. 2. Additional beams will prevent the wheel from swaying. In principle, the muon system can roll with the toroid if one needs to move the toroids to service accelerator magnets.

We plan to install over a long period of time, as octants become available, and during extended shutdowns.

**Low and high voltage, DAQ hardware installation:** These items will hopefully be available as needed, *i.e.* as new octants are installed. We will install them at the same time as their corresponding octants, or ahead of time if they are available.

**Connection of electrical, gas, and electronics:** Once all the octants in a wheel are installed we make all gas, electrical, data acquisition, and slow control connections. We will then proceed to test these connections as described below.

## 3.2 Equipment required

For installation, special rigging will need to be assembled; again this will be provided by Illinois. This is envisioned as a special installation arm and guide rod that attach to an octant. A rail and pulleys will then allow manipulation of each octant as it is being positioned into its mounting wheel.

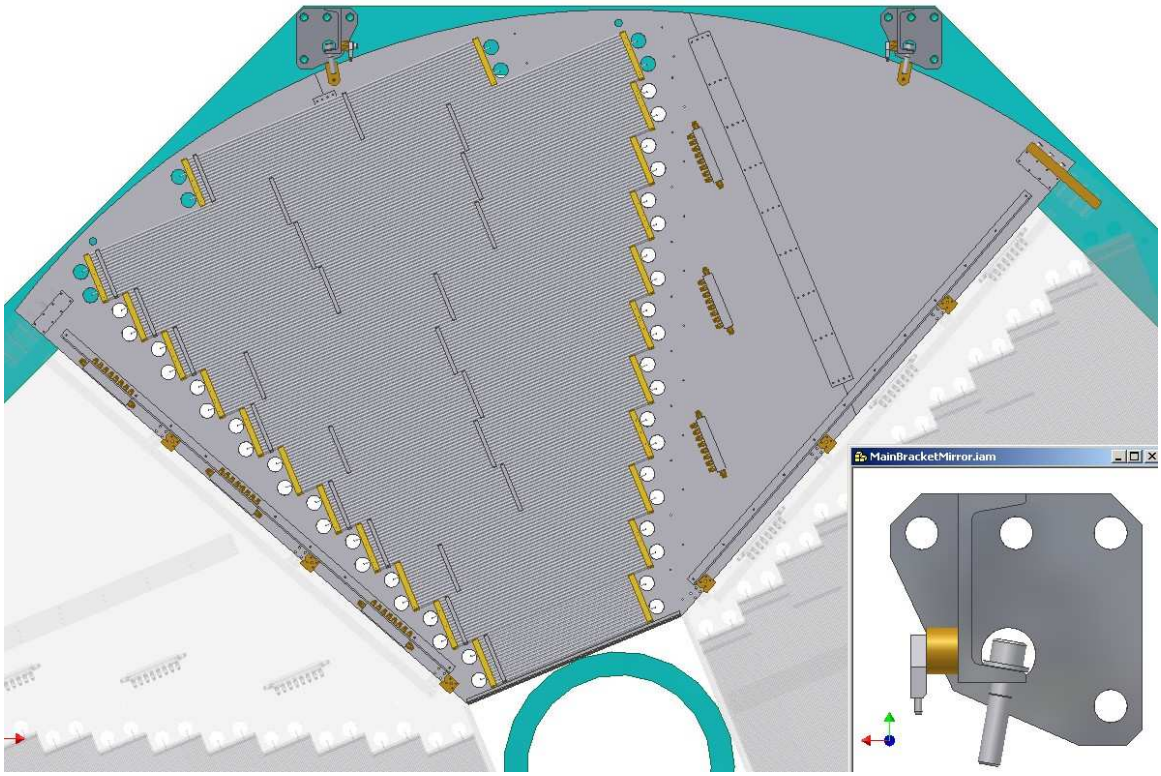


Figure 2: Details of the hanging brackets used to support the octant plate wheel assemblies.

## 3.3 Personnel required

The octants will be installed by members of the muon group. However, the support structure (beams) for the views will need to be installed by Fermilab personnel (welders, riggers,...). In addition, DAQ personnel may be needed to help with connection of the octants to the DAQ.

## 3.4 Time required

We estimate that it will take up to 12 hours to install each wheel of 4 octants, which translates to 4 days per station or 12 days for the full detector. This does not include connections, which we estimate will take an equal amount of time. We believe the time to install octants will decrease as we get better at it. Note that in real time this will take roughly two years, as we plan to install octants as they become available and as opportunities exist to gain access to the experimental hall for extended periods. The first octants should start arriving at C0 in late 2006. The final octants should be ready by the summer of 2008.

# 4 Testing of muon system elements at C0

## 4.1 Stand-alone subsystem testing

**Mechanical:** As each octant is installed, the gas system will be tested for leaks and proper flow.

**Electrical/electronics:** As each octant is installed and connected, we will (carefully) bring them up to voltage and verify that they are drawing the expected current. We will check a channel or two in each plank with a scope to verify that they seem to be behaving as expected (expected noise level, signals look OK, etc.). We will then readout each channel and verify that each is connected to the DAQ and functioning as expected.

**Software:** When a view is installed, we should be able to look for cosmic rays, and to look at beam background when the accelerator is on. As we add views to each station, we can start to do more sophisticated tests and can start to debug our readout software, reconstruction software, and the muon trigger. We may determine the installation order to make best use of these kinds of tests.

**Personnel required:** Muon group (and muon trigger group) personnel can perform all stand alone testing, although some interaction with the DAQ and trigger groups will be important.

**Time required:** This activity will go on over an extended period of time (two years), as described above. This will give us plenty of time to debug our software and to perform multiple tests; we should not have a problem keeping up.

## 4.2 Combined systems testing

**Electrical/electronics/readout/software:** We hope to be using the DAQ early on, even in our "stand alone" tests. We also hope to use these tests to debug the muon trigger. So, the above "stand alone" tests will also be integration tests with the DAQ and trigger, two important elements that we connect with. We also will want to investigate higher level triggering, which will require information from the tracking systems. Once the tracking systems become available, we will start these tests.

**Personnel required:** Muon group (and muon trigger group) personnel will participate. Some interaction with the DAQ, trigger, and tracking groups will be required.

**Time required:** This activity will go on over an extended period of time (two years), as described above. This will give us plenty of time to debug our software and to perform multiple tests; we should not have a problem keeping up.

## 4.3 Completion of commissioning

The muon detector will be considered fully commissioned when the entire system is under voltage, gas is flowing, and near-horizontal hits from cosmic rays or beam backgrounds are able to be read out through the DAQ.